Fig.3.1 Dispersion of an isolated source (defined in text(3.3)) initially at 45N and the dateline using propagating zonal harmonics. The wave speeds are derived empirically from a multi-year 500 mb height daily data set in January. The four panels show the result after zero (upper left), one, two and five days (lower right). The geography is for orientation only. Contours every 20gpm. Positive values light shading, negative values darker shading. Negative contours are dashed.

Fig.3.2 As Fig. 3.1 Dispersion of the same isolated source at 45N, but now using propagating spherical harmonics. The wave speeds are derived from a multi-year 500 mb height daily data set in January. The four panels show the result after zero (upper left), one, two and five days (lower right). The geography is for orientation only. The contours are every 20 gpm. Positive values light shading, negative values darker shading. Negative contours are dashed. (The amplitude of the initial source is taken 3 times larger as in Fig.3.1 to accommodate the loss of amplitude due to dispersion over the global domain.)

Fig. 3.3. The percent improvement of rmse of 1-day EWP forecasts over Persistence along 50N (dashed line) and 50S (solid line) in DJF. For zonal waves 6 and 7 the rms error in the SH is cut in half by taking wave motion (as per EWP) into account

Fig.3.4 The amplitude and phase speed (m/s) in April for zonal harmonic waves, as a function of zonal wavenumber and latitude, in 200 mb velocity potential as determined from 12 hourly data for the period 1979-2003. The zonal wavenumber (1 to 30) is on a log scale. Unit for the amplitude is 10**6 m*m/s. Negative values are shaded. Negative contours are dashed.

Fig.4.1 Display of Teleconnection for seasonal (JFM) mean 500 mb height. Shown are the correlation between the basepoint (noted above the map) and all other gridpoints (maps) and the timeseries of 500mb height anomaly (geopotential meters) at the basepoints. Contours every 0.2, starting contours +/- 0.3. Data source: NCEP Global Reanalysis. Period 1948-2005. Domain 20N-90N. On the left a pattern referred to as North Atlantic Oscillation (NAO). On the right the Pacific North American pattern (PNA).

Fig.4.2. Same as Fig 4.1, but now the base point is at 2.5S and 170E, i.e. outside the display area. Positive values light shading, negative values darker shading. Negative contours are dashed.

Fig. 4.3 EV(I), the domain variance explained by single gridpoints in % of the total variance of seasonal (JFM) mean Z500 over 1948-2005, using equation 4.3. In the upper left for raw data, in the upper right after removal of the first EOT mode, lower left after removal of the first two modes etc. Contours every 4%. Values in excess of 4% lightly shaded, in excess of 12% dark shading. The timeseries shown are the residual height anomaly at the gridpoint that explains the most of the remaining domain integrated variance.

Fig.4.4 Display of four leading EOT for seasonal (JFM) mean 500 mb height. Shown are the regression coefficient between the height at the basepoint and the height at all other gridpoints (maps) and the timeseries of the residual 500mb height anomaly (geopotential meters) at the basepoints. In the upper left for raw data, in the upper right after removal of the first EOT mode, lower left after removal of the first two modes etc. Contours every 0.2, starting contours +/- 0.1. Data source: NCEP Global Reanalysis. Period 1948-2005. Domain 20N-90N

Fig.5.1 Display of the four leading EOFs for seasonal (JFM) mean 500 mb height. Shown are the maps and the time series. A postprocessing is applied, see Appendix I, such that the physical units (gpm) are in the time series, and the maps have norm=1. Contours every 0.2, starting contours +/- 0.1. Data source: NCEP Global Reanalysis. Period 1948-2005. Domain 20N-90N. The seed basepoint (e.g. 65N,50W) is mentioned because the iteration towards EOF (as described in Appendix II) starts from the EOT.

Fig.5.2. Same as Fig 5.1, but now daily 0Z data for all Decembers, Januaries and Februaries during 1998-2002

Fig.5.3. Same as Fig 5.2, but now the SH.

Fig.5.4 Display of four leading alternative EOTs for seasonal (JFM) mean 500 mb height. Shown are the regression coefficient between the basepoint in time (1989 etc) and all other years (timeseries) and the maps of 500mb height anomaly (geopotential meters) observed in 1989, 1955 etc . In the upper left for raw data, in the upper right map after removal of the first EOT mode, lower left after removal of the first two modes etc. A postprocessing is applied, see Appendix I, such that the physical units (gpm) are in the time series, and the maps have norm=1. Contours every 0.2, starting contours +/- 0.1. Positive values light shading, negative values darker shading. Negative contours are dashed. Data source: NCEP Global Reanalysis. Period 1948-2005. Domain 20N-90N

Fig.5.5, the same as Fig 5.1, but obtained by starting the iteration method (see Appendix II) from alternative EOTs, instead of regular EOT. Compared to Fig.5.1 only the polarity may have changed. Positive values light shading, negative values darker shading. Negative contours are dashed.

Fig.5.6: Summary of EOT/F procedures

Fig 5.7. Explained Variance (EV) as a function of mode (m=1,25) for seasonal mean (JFM) Z500, 20N-90N, 1948-2005. Shown are both EV(m) (scale on the left, triangles) and cumulative EV(m) (scale on the right, squares). Red lines are for EOF, and blue and green for EOT and alternative EOT respectively.

Fig.5.8 Display of four leading EOFs for seasonal (OND) mean SST. Shown are the maps on the left and the time series on the right. Contours every 1C, and a color scheme as indicated by the bar. Data source: NCEP Global Reanalysis. Period 1948-2005. Domain 45S-45N

Fig.5.9 Display of four leading EOFs for seasonal (JFM) mean 500 mb streamfunction. Shown are the maps and the time series. A postprocessing is applied, see Appendix I, such that the physical units (10**7 m*m/s) are in the time series, and the maps have norm=1. Contours every 0.2, starting contours +/- 0.1. Data source: NCEP Global Reanalysis. Period 1948-2005. Domain 20N-90N

Fig. 6.1 The seasonal cycle of N, the effective degrees of freedom (dof; non-dimensional), and the standard deviation (sd; gpm) for 500 mb daily height for the NH (20N-pole) and the SH (20S-pole). Period analyzed is 1968-2004. The lines for sd are in red, for dof in blue. The lines for NH are full lines connecting squares, for SH dashed lines connecting triangles

Fig.6.2 The dependence of the degrees of freedom (N), full line, on the lead of the forecast in a 5 year retrospective forecast data set with a T62L28 NCEP model of vintage 2002. The dashed line is the standard deviation around the model's climate mean. Domain 20N-North Pole.

Fig. 7.1 The most similar looking 500 mb flow patterns in recorded history on a domain this size (20^{o} to the pole). These particular analogues were found for the SH, 20S-90S, and correlate at 0.81. The climatology, appropriate for the date and the hour of the day, was removed. Contours every 40gpm. Positive values light shading, negative values darker shading. Negative contours are dashed.

Fig. 7.2: The idea of analogues. For a given 'base', which could be today's weathermap, we seek in an historical data set for an analogue in roughly the same time of the year. The base and analogue are assigned t=0. The string of weathermaps following the analogue would be the forecast for what will follow the base. (Data permitting there could be more than one analogue.) As a process this is comparable to 'integrating' the model equations starting from an analysis at t=0, an analysis which is as close as possible to the true base. 'Nature' stands for a perfect model.

Fig. 7.3 The average correlation between a given flow and the nearest neighbor (analog) and the farthest removed flow (anti-analog; sign reversed) as a function of month. The record best analogs and antilogs are given by the upper lines. The domain is 20N to the pole, the variable is daily 500 mb height at 0Z, and the years 1968-2004.

Fig. 7.4 (a) The observed anomaly in monthly mean stream function (upper left), the same in b) but truncated to 50 EOFs, the constructed analogue in c) and the difference of c) and a) in d). Unit is 10**7 m*m/s, contour interval 0.2*10**7 m*m/s. Results for February 1998. Domain 20N-North Pole. Positive values light shading, negative values darker shading. Negative contours are dashed.

Fig. 7.5(a) The observed anomaly in monthly mean 850 mb temperature (upper left), the specified 850 mb temperature by the constructed analogue in c) and the difference of c) and a) in d). Contour interval 1K. Results for February 1998. Map b) is intentionally left void.

Fig.7.6: The skill (ACX100) of forecasting seasonal mean NINO34 SST by the CA method for the period 1956-2005. The plot has the target season in the horizontal and the lead in the vertical. Example: NINO34 in rolling seasons 2 and 3 (JFM and FMA) are predicted slightly better than 0.7 at lead 8 months. An 8 month lead JFM forecast is made at the end of April of the previous year. A 1-2-1 smoothing was applied in the vertical to reduce noise. Values larger than 0.6 are shaded.

Fig. 7.7 An ensemble of 12 CA forecasts for seasonal mean Nino34 SST. The release time is July 2005, data through the end of June were used. Observations (3 mo means) for the most recent 6 overlapping seasons are shown as red dots. The ensemble mean is the black line with closed black circles. The CA ensemble members were created by different EOF truncation etc (see text).

Fig.7.8: Dispersion of the source shown at 45N and 180W in upper left, out to 3 days. The dispersion is calculated through an analogue constructed to the initial state. The initial source is identically the same in both shape and magnitude as in Fig.3.1. Contours every 20gpm. Positive values light shading, negative values darker shading. Negative contours are dashed.

Fig.7.9: Dispersion two days after a sources was released at 45N and longitudes 0E, 90E, 180W and 90W respectively. For ease of comparison the plots have been rotated such that the longitude of release is at the bottom in all four cases. Contours every 20gpm. Positive values light shading, negative values darker shading. Negative contours are dashed.

Fig.7.10a The fastest growing modes determined by repeated application of the CA operator for $\Delta t = 2$ days on January 500 mb height data, 20N-pole. Spatial patterns of the first complex mode are on the top row. The 2nd mode (bottom row) has zero frequency - only a real part exists. Units for the maps are gpm/100 multiplied by the inverse of re-scaling (close to unity usually) applied to the time series Fig.7.10b. Contours every 50gpm. Positive values light shading, negative values darker shading. Negative contours are dashed.

Fig.7.10b The amplitude time series (scaled to +/-1; left hand scale) and amplitude growth rate (% per day; right hand scale) of the fastest growing mode, plotted every 30th day. The time series and growth rates multiply the patterns shown in the top row of Fig.7.10a.

Fig 8.1 Month-to-month autocorrelation (X100) of monthly mean temperature over the US at lag 1 and 2 months, as a function of target month.

Fig. 8.2: The difference between the temperature averaged over the last 10 years and the 30 year climatological mean for the four seasons over the US. Units are in % of the local standard deviation. Contours every 20. Positive values light shading, negative values (only in MAM and JJA) darker shading. Negative contours are dashed.

Fig. 8.3 The local correlation (X100) between antecedent soil moisture and subsequent temperature over the US. Results are aggregated over 102 super Climate Divisions. Contours every 0.15. Positive values light shading, negative values darker shading. Negative contours are dashed.

Fig.8.4 : The correlation (X100) between soil moisture at the end of February and the co-located temperature in February (lag 0) through May (lag 3). Correlations in excess of +/-0.15 are shaded. Contours every 0.15.

Fig. 8.5. The zonal mean zonal wind at 30mb at the equator from 1948 through September 2005. The time mean is removed. All data is monthly mean. Source is the global NCAR/NCEP Reanalysis

Fig. 8.6: The correlation (*100.) between the Nino34 SST index in fall (SON) and the temperature (top) and precipitation (bottom) in the following JFM in the United States. Correlations in excess of +/-0.1 are shaded. Contours every 0.1. Positive values light shading, negative values darker shading. Negative contours are dashed.

Fig. 9.1 Typical decrease of anomaly correlation of daily Z500 forecasts as a function of lead time (black dashes). From a practical point of view skill is too low for day-by-day forecasting after 5, 10 or 15 days (depending on criterion). However, the correlation remains slightly positive at longer leads (even after 30 days). From Jae Schemm's 5 year calibration data set (NCEP-GFS model)

Fig. 9.2 A lay-out of the seasonal forecast, showing the averaging time, and the lead time (in red). Rolling seasonal means at leads of 2 weeks to 12.5 months leads are being forecast. The forecast for the first season starts where the short-range and week2 forecats leave off.

Fig. 9.3: The climatological pdf (blue) and a conditional pdf (red). The integral under both curves is the same, but due to a predictable signal the red curve is both shifted and narrowed. In the example the predictor-predictand correlation is 0.5 and the predictor value is +1. This gives a shift in the mean of +0.5, and the standard deviation of the conditional distribution is reduced to 0.866. Units are in standard deviations (x-axis). The dashed vertical lines at +/- 0.4308 separate a Gaussian distribution into three equal parts.

Fig.9.4: An example of a recently released forecasts for AMJ 2006, T on the left and P on the right. Contours are absolute probabilities at 33%, 40, 50 and 60%. The color and

the letters A or B indicate the shift in probability towards Above (A, T red, P green) or Below (B, T blue, P brown). White areas labeled EC have climatological probabilities for all three classes.

Fig.9.5 The probability shift (contours), relative to 100*1/3rd, in the above normal class as a function of a-priori correlation (R , y-axis) and the standardized forecast of the predictand (F, x-axis). The result is based on shifting and or shrinking (the standard deviation of) a Gaussian distribution. The probability anomaly increases with both F and R. (Source: Dave Unger.

Fig.9.6 The looks of a tool used to make the seasonal prediction. The tool is the CCA. The units are standard deviations multiplied by 10. Red (blue) values are positive (negative) anomalies. The size of the numeral indicates the level of a-priori skill. At the locations, indicated by only the red or blue plus sign, the a-priori skill is below the 0.3 correlation, and forecast value is shown.

Fig 10.1 The anomaly correlation of bias corrected seasonal mean ensemble mean DJF Z500 simulations (in four AMIP simulations 1950-1994) as a function of the bias. Domain: 20N-pole. The participating models are from IRI, NCEP, NCAR and GFDL.